









# EFFECTS OF AUGMENTED REALITY COLOURING APPLICATION TOWARDS CREATIVE THINKING AMONG PRESCHOOL CHILDREN THROUGH COMPUTERISED MEASUREMENT







# SULTAN IDRIS EDUCATION UNIVERSITY 2019





















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### FADILAH BINTI ABDUL RAUF











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### **ABSTRACT**

This study aimed to investigate the effects of augmented reality (AR) colouring application towards the preschool children's creative thinking. An instrument adapted from Torrance Test of Creative Thinking was developed and verified by five subject matter experts. An application titled FARCCS was created to computerise the measurement. Data collected through manual measurement were compared against the computerised measurement. The results showed statistical significant differences, indicating that the computerised measurement was more accurate and reliable, apart from being faster than human assessor. The effects of the AR colouring application were investigated through two quasi-experimental studies which were conducted in Kelantan, Malaysia. The first study was a single-group pre- and post-test quasiexperiment, conducted with 10 preschool children in School A, while the second study was a pre- and post-test control group quasi-experiment, carried out with 50 preschool children in School B. The data were analysed using nonparametric statistics, involving Mann-Whitney U test and Wilcoxon Signed Ranks test. The average scores of both studies improved significantly (School A: Z = -2.565, p < 0.05, Median = Very Good; School B: U = 201.5, Z = -3.494, p < 0.05, Median = Excellence). Results of the first study showed significant improvement in post-test fluency score (Z = -2.0, p < 0.05, Median = Fair), as compared to the pre-test fluency score. Meanwhile, results of the second study revealed significant improvement in originality scores (U = 214.50, Z = -3.204, p < 0.05, Median = Fair), as compared to the teaching and learning without AR. In conclusion, AR colouring application can be used to improve the fluency and originality aspects of creative thinking among preschool children. Implication of this research was, teaching and learning with AR for colouring activities in preschool settings can be practiced to develop creative thinking skills of the children.



















# KESAN PERISIAN MEWARNA REALITI TERIMBUH TERHADAP PEMIKIRAN KREATIF DALAM KALANGAN MURID PRASEKOLAH MELALUI PENGUKURAN BERKOMPUTER

### **ABSTRAK**

Kajian ini bertujuan untuk mengkaji kesan perisian mewarna realiti terimbuh (AR) terhadap pemikiran kreatif dalam kalangan murid prasekolah. Satu instrumen yang diadaptasi dari Torrance Test of Creative Thinking telah dibangunkan dan disahkan oleh lima orang pakar pakar bidang khusus. Satu perisian bertajuk FARCCS telah dibangunkan bagi mengautomasikan pengukuran berkenaan. Data yang dikumpulkan melalui pengukuran manual dibandingkan dengan pengukuran berkomputer. Dapatan menunjukkan terdapat perbezaan statistik yang signifikan, menunjukkan pengukuran berkomputer lebih tepat dan konsisten, malah lebih cepat dari manusia sebagai pengukur. Kesan perisian mewarna dengan AR dikaji melalui dua kajian kuasieksperimen yang dijalankan di Kelantan, Malaysia. Kajian pertama ialah ujian pra-dan pasca kuasi-eksperimen bagi satu kumpulan yang melibatkan 10 kanak-kanak prasekolah di Sekolah A, manakala kajian kedua ialah ujian pra- dan pasca kuasieksperimen bagi kumpulan kawalan yang melibatkan 50 kanak-kanak prasekolah di Sekolah B. Data dianalisis dengan menggunakan ujian non-parameter, melibatkan ujian Mann-Whitney U and ujian Wilcoxon Signed Ranks. Skor purata dalam kedua-dua kajian menunjukkan peningkatan yang signifikan (Sekolah A: Z = -2.565, p < 0.05, Median = Sangat Baik; Sekolah B: U = 201.5, Z = -3.494, p < 0.05, Median = Cemerlang). Dapatan kajian pertama menunjukkan peningkatan yang signifikan dalam ujian-pasca bagi skor kelancaran (Z = -2.0, p < 0.05, Median = Sederhana), berbandingujian-pra bagi skor kelancaran. Sementara itu, dapatan kajian kedua menunjukkan bahawa skor keaslian meningkat secara signifikan (U = 214.50, Z = -3.204, p < 0.05, Median = Sederhana), berbanding dengan pengajaran dan pembelajaran (PdP) tanpa AR. Kesimpulannya, perisian mewarna AR boleh digunakan bagi meningkatkan aspek kelancaran dan keaslian pemikiran kreatif dalam kalangan kanak-kanak prasekolah. Implikasi kajian ini ialah, PdP dengan AR bagi aktiviti mewarna dalam persekitaran prasekolah boleh diamalkan bagi membangunkan pemikiran kreatif kanak-kanak.





















# TABLE OF CONTENTS

				Pages	
	DECLARATION OF ORIGINAL WORK  DECLARATION OF THESIS  ACKNOWLEDGEMENT  ABSTRACT  ABSTRAK  CONTENTS  LIST OF TABLES  LIST OF FIGURES  05-45068 LIST OF ABREVIATIONS F Respussalean Tunku Bahun  Kempus Sultan Abdul Jalil Shah  LIST OF APPENDICES  CHAPTER 1 INTRODUCTION  1.1 Overview  1.2 Background of the Research  1.3 Problem Statement  1.4 Research Aim and Objectives  1.5 Research Questions and Hypotheses  1.6 Conceptual framework		ii		
DECLARATION OF ORIGINAL WORK  DECLARATION OF THESIS  ACKNOWLEDGEMENT  ABSTRACT  ABSTRAK  CONTENTS  LIST OF TABLES  LIST OF FIGURES  OS-4506  LIST OF ABREVIATIONS Perpettikaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah  LIST OF APPENDICES  CHAPTER 1 INTRODUCTION  1.1 Overview  1.2 Background of the Research  1.3 Problem Statement  1.4 Research Aim and Objectives  1.5 Research Questions and Hypotheses		iii			
	DECLARATION OF ORIGINAL WORK  DECLARATION OF THESIS  ACKNOWLEDGEMENT  ABSTRACT  ABSTRAK  CONTENTS  LIST OF TABLES  LIST OF FIGURES  05-4506 LIST OF ABREVIATIONS  Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah  LIST OF APPENDICES  CHAPTER 1 INTRODUCTION  1.1 Overview  1.2 Background of the Research  1.3 Problem Statement  1.4 Research Aim and Objectives  1.5 Research Questions and Hypotheses  1.6 Conceptual framework  1.7 Theoretical Framework		iv		
	DECLARATION OF ORIGINAL WORK  DECLARATION OF THESIS  ACKNOWLEDGEMENT  ABSTRACT  ABSTRAK  CONTENTS  LIST OF TABLES  LIST OF FIGURES  05-4506 LIST OF ABREVIATIONS Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah  LIST OF APPENDICES  CHAPTER 1 INTRODUCTION  1.1 Overview  1.2 Background of the Research  1.3 Problem Statement  1.4 Research Aim and Objectives  1.5 Research Questions and Hypotheses  1.6 Conceptual framework  1.7 Theoretical Framework			v	
DECLARATION OF ORIGINAL WORK  DECLARATION OF THESIS  ACKNOWLEDGEMENT  ABSTRACT  ABSTRAK  CONTENTS  LIST OF TABLES  LIST OF FIGURES  OS-45000 LIST OF ABREVIATIONS   Perputakaan Tuanku Banun Rampus Sultan Abdul Jaill Shah  LIST OF APPENDICES  CHAPTER 1 INTRODUCTION  1.1 Overview  1.2 Background of the Research 1.3 Problem Statement 1.4 Research Aim and Objectives 1.5 Research Questions and Hypotheses 1.6 Conceptual framework 1.7 Theoretical Framework				vi	
DECLARATION OF ORIGINAL WORK  DECLARATION OF THESIS  ACKNOWLEDGEMENT  ABSTRACT  ABSTRAK  CONTENTS  LIST OF TABLES  LIST OF FIGURES  OS-45048 LIST OF ABREVIATIONS T Perpustakaan Tuanku Banun Rampus Sultan Abdul Jalil Shah  LIST OF APPENDICES  CHAPTER 1 INTRODUCTION  1.1 Overview  1.2 Background of the Research  1.3 Problem Statement  1.4 Research Aim and Objectives  1.5 Research Questions and Hypotheses  1.6 Conceptual framework  1.7 Theoretical Framework				vii	
	LIST OF TAB	LES		xvi	
	LIST OF FIG	URES		xxi	
05-450	DECLARATION OF ORIGINAL WORK  DECLARATION OF THESIS  ACKNOWLEDGEMENT  ABSTRACT  ABSTRAK  CONTENTS  LIST OF TABLES  LIST OF FIGURES  VIX  LIST OF ABREVIATIONS   Purpustalean Tuanku Bainun Kompus Suhan Abdul Jail Shah  LIST OF APPENDICES  CHAPTER 1 INTRODUCTION  1.1 Overview 1.2 Background of the Research 1.3 Problem Statement 1.4 Research Aim and Objectives 1.5 Research Questions and Hypotheses 1.6 Conceptual framework 21				
	DECLARATION OF ORIGINAL WORK  DECLARATION OF THESIS  ACKNOWLEDGEMENT  ABSTRACT  ABSTRAK  CONTENTS  LIST OF TABLES  LIST OF FIGURES  OS 45068 LIST OF ABREVIATIONS  Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah  LIST OF APPENDICES  XXX  CHAPTER 1 INTRODUCTION  1.1 Overview  1.2 Background of the Research  1.3 Problem Statement  1.4 Research Aim and Objectives  1.5 Research Questions and Hypotheses  1.6 Conceptual framework  2 2			xxvii	
	DECLARATION OF THESIS  ACKNOWLEDGEMENT  ABSTRACT  ABSTRAK  CONTENTS  LIST OF TABLES  LIST OF FIGURES  O5-45004 LIST OF ABREVIATIONS T Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah  LIST OF APPENDICES  CHAPTER 1 INTRODUCTION  1.1 Overview  1.2 Background of the Research  1.3 Problem Statement  1.4 Research Aim and Objectives  1.5 Research Questions and Hypotheses  1.6 Conceptual framework  1.7 Theoretical Framework				
		1.1	Overview	1	
		1.2	Background of the Research	2	
		1.3	Problem Statement	8	
		1.4	Research Aim and Objectives	12	
		1.5	Research Questions and Hypotheses	13	
		1.6	Conceptual framework	21	
		1.7	Theoretical Framework	24	
		1.8	Research scope	27	















	1.8.1	The Participants	28
	1.8.2	The Device Used	29
	1.8.3	The App and Colouring Worksheet	29
1.9	Signifi	cance of this Research	30
1.10	Operat	ional definition	31
	1.10.1	Creative Thinking	31
	1.10.2	Fluency	31
	1.10.3	Flexibility	31
	1.10.4	Originality	32
	1.10.5	Elaboration	32
1.11	Summa	ary	32

# 05-45068 CHAPTER 2 LITERATURE REVIEW Abdul Jalil Shah





2.1	Introduction	33	

2.2	Preschool Education in Malaysia	36

- Relationship between Creativity and Colouring 42 2.2.1 in Preschool Syllabus
- Colouring Activities as a Filler of Teaching and 44 2.2.2 Learning

2.3	Augmented Reality (AR)	46
5	raginented reduity (ritt)	10

- 2.3.1 AR for Preschool in Various Fields 47
- AR for Preschool in Creative Thinking 52 2.3.2 **Colouring Activities**
- 56 2.4 Assessment in Creative Thinking
- 2.5 Effect of Colouring Activity on Creative Thinking and 63 its Four Constructs

















	2.6	Summary	68
CHAPTER 3	МЕТНО	DOLOGY	
	3.1	Introduction	69
	3.2	Epistemological Paradigm	70
	3.3	Research Variables	71
	3.4	Research Design	72
	3.5	Data collection procedure	73
	3.6	Population and sample	74
	3.7	Preliminary Investigation	75
		3.7.1 Collecting Data Using the Quiver 3D Colour App	ring 76
506832 pustak	a.upsi.edu.my	3.7.2 Results of Preliminary Investigation  Kampus Sultan Abdul Jalil Shah  Experimental Studies	83 ptbu
		3.8.1 Single-Group Pre- and Post-test Quasi- experiment	88
		3.8.2 Pre- and Post-test Control Group Quasi- experiment	95

#### **INSTRUMENTATION CHAPTER 4**

3.9

3.10

3.11

Data Analysis

Summary

**Provisional Guiding Principles** 

4.1	Introduction	108

4.2 Instrumentation through Adaptation of Existing Tools 109











103

104

106







		4.3	Valida and Sc	tion of the Proposed Instrument cales	114
			4.3.1	Validation of the Fluency Construct	115
			4.3.2	Validation of the Flexibility Construct	116
			4.3.3	Validation of the Originality Construct	117
			4.3.4	Validation of the Elaboration Construct	118
		4.4	Comp	uterisation of Manual Measurement	119
		4.5		ical Comparison between the Manual rement and the Computerised Measurement.	128
			4.5.1	Normality Test	129
				4.5.1.1 Normality Test for the Single-Group Pre- and Post-test Quasi-experiment	129
				4.5.1.2 Normality Test for the Pre- and Post- test Control Group Quasi-experiment	132
05-4506832	pustaka.u			Hypotheses Generated for Statistical Comparison Tests Between Manual and Computerised Measurement	135
			4.5.3	Finding for Statistical Comparison Between Manual and Computerised Measurement	136
		4.7	Summ	ary	140
СН	APTER 5	ANALYS	SIS AN	D FINDINGS	
		5.1	Introdu	uction	141
		5.2		gs of the Single-Group Pre- and Post-test experiment	142
			5.2.1	Demographic Profile of Research Participants from School A	143
			5.2.2	Sample Characteristics of Participants in School A	144



















		5.2.3	Comparison of the Overall Scores between Pre-test and Post-test	145
		5.2.4	Overall Pre-test and Post-test Performance	147
			5.2.4.1 Overall Scores Comparison between Pre-test and Post-test Average Scores	147
			5.2.4.2 Overall Scores Comparison between Pre-test and Post-test Fluency Scores	148
			5.2.4.3 Overall Score Comparison between Pre-test and Post-test Flexibility Scores	150
			5.2.4.4 Overall Score Comparison between Pre-test and Post-test Originality Score	151
			5.2.4.5 Overall Score Comparison between Pre-test and Post-test Elaboration Score	152 e
	5.3		ngs of the Pre- and Post-test Control Group experiment	154
05-4506832	pustaka.upsi.edu.my	5.3.1	Demographic Profiles of Research Participants in School B	159
		5.3.2	Sample Characteristics of School B	161
		5.3.3	Comparison of the Overall Scores between the Control Group and the Experimental Group	165 p
		5.3.4	Overall Pre-test and Post-test Performance	167
			5.3.4.1 Pre-test Scores Comparison between Overall Control and Experimental Grou	168 up
			5.3.4.2 Post-test Scores Comparison between Overall Control and Experimental Grou	169 ap
			5.3.4.3 Overall Score Comparison between Pre-test and Post-test Average Score	170
			5.3.4.4 Overall Score Comparison between Pre-test and Post-test Average Scores in the Control Group	172 n
			5.3.4.5 Overall Score Comparison between Pre-test and Post-test Average Scores in the Experimental Group	173 n



















5.3.5	Fluency Construct for Pre-test and Post-test	174
	Performance	

- 5.3.5.1 Pre-test Fluency Scores Comparison between the Control and the Experimental Group
- 5.3.5.2 Post-test Fluency Scores Comparison 176 between the Control and the Experimental Group
- 5.3.5.3 Overall Score Comparison between Pre-test and Post-test Fluency Scores
- 5.3.5.4 Overall Score Comparison between Pre-test and Post-test Fluency Scores in the Control Group
- 5.3.5.5 Overall Score Comparison between Pre-test and Post-test Fluency Scores in the Experimental Group
- 5.3.6 Flexibility Construct for Pre-test and Post-test 181 Performance



- 5.3.6.1 Pre-test Flexibility Scores Comparison 181 between the Control and the Experimental Group
- 5.3.6.2 Post-test Flexibility Scores Comparison 183 between the Control and the Experimental Group
- 5.3.6.3 Overall Score Comparison between Pre-test and Post-test Flexibility Scores
- 5.3.6.4 Overall Score Comparison between Pre-test and Post-test Flexibility Scores in the Control Group
- 5.3.6.5 Overall Score Comparison between Pre-test and Post-test Flexibility Scores in the Experimental Group
- 5.3.7 Originality Construct for Pre-test and Post-test 188 Performance
  - 5.3.7.1 Pre-test Originality Scores Comparison 188 between the Control and the





















### **Experimental Group**

5.3.7.2 Post-test Originality Scores	189
Comparison between the Control and	the
Experimental Group	

- 5.3.7.3 Overall Score Comparison between 191 Pre-test and Post-test Originality Scores
- 5.3.7.4 Overall Score Comparison between 192 Pre-test and Post-test Originality Scores in the Control Group
- 5.3.7.5 Overall Score Comparison between 193 Pre-test and Post-test Originality Scores in the Experimental Group
- 5.3.8 Elaboration Construct for Pre-test and Post-test 194 Performance
  - 195 5.3.8.1 Pre-test Elaboration Scores Comparison between the Control and the **Experimental Group**





- 5.3.8.2 Post-test Elaboration Scores 196 toupsi Comparison between the Control and the **Experimental Group**
- 5.3.8.3 Overall Score Comparison between 197 Pre-test and Post-test Elaboration Scores
- 5.3.8.4 Overall Score Comparison between 199 Pre-test and Post-test Elaboration Scores in the Control Group
- 5.3.8.5 Overall Score Comparison between 200 Pre-test and Post-test Elaboration Scores in the Experimental Group
- 5.4 Summary

201

#### **DISCUSSION, CONCLUSION & RECOMMENDATIONS CHAPTER 6**

- 6.1 Introduction 209
- 6.2 Answers to the Research Questions 210











		6.2.1	Q1: Is there a significant difference of preschool children's creative thinking before and after using the AR colouring mobile app?	211
		6.2.2	Q2: Is there a significant difference in the use of multiple colours among preschool children before and after using AR colouring mobile app?	216
		6.2.3	Q3: Is there a significant difference in the use of multiple colouring techniques among preschool children before and after using AR colouring mobile app?	221
		6.2.4	Q4: Is there a significant difference in the attempt of adding new object in colouring activity among preschool children before and after using AR colouring mobile app?	225
		6.2.5	Q5: Is there a significant difference in the choice of colour weight in colouring activity among preschool children before and after usin AR colouring mobile app?	230 ng
05-4506832	pustaka.u.6.3edu.my		s of AR Colouring Mobile App towards we Thinking	235
		6.3.1	Effects of AR Colouring Mobile App towards TTCT Average Score	235
		6.3.2	Effects of AR Colouring Mobile App towards Fluency	237
		6.3.3	Effects of AR Colouring Mobile App towards Originality	239
	6.4	Contri	butions of the Thesis	240
		6.4.1	The Guiding Principle	241
		6.4.2	Teacher-led Instruction for Teaching Children Colouring using AR App	246
		6.4.3	FAR Creative Colouring Scanner Software	252





6.5



Research Conclusion





256











6.6	Implication and Potential Future Studies	259
-----	--	-----

**REFERENCES** 261

**APPENDICES** 272































# LIST OF TABLES

	Table N	Po.	age
	1.1	Hypotheses of the Single-Group Pre- and Post-test Quasi-experiment	15
	1.2	Hypotheses of the Pre- and Post-test Control Group Quasi-experiment	16
	2.1	Electronic Databases	34
	2.2	Database Search Result Related to: creative thinking, preschool and colouring	38
	2.3	Research on Creative Thinking among Preschool Children	40
	2.4	Specific Performance Standards for Three Levels of Mastery in Creativity and Aesthetics (Adapted from Bahagian Pembangunan Kurikulum, 2016, p. 152)	43
05-4506	2.5	Activities Involved Colour (shaded in grey) in Five of Six Core in Preschool Syllabus adapted from Malaysian Preschool Syllabus (Bahagian Pembangunan Kurikulum, 2010)	45 ptbu
	2.6	Database Search Result Related to: augmented, reality and preschool	48
	2.7	Positive Effects of AR for Preschool in Various Fields	51
	2.8	Database Search Result Related to: connectivism, creative thinking, preschool and colouring	53
	2.9	Database Search Result Related to: measurement, creative thinking and preschool	57
	2.10	Database Search Result Related to: measurement, creative thinking, preschool and colouring	58
	2.11	Database Search Result for TTCT	60
	2.12	Comparison of Creative Thinking Assessment	62
	2.13	Database Search Result Related to: effect, colouring, creative thinking TTCT constructs and preschool	64
	3.1	Methodology of Three-phase Research	72
	3.2	Participants in the Preliminary Investigation	76
	3.3	Results of the Preliminary Investigations	84





















3.4	The First Version of Guiding Principles	86
3.5	Research Protocol in the Single-group Pre- and Post-tests Quasi- experimental Study	92
3.6	The Results of the Simple Random Sampling	98
3.7	Protocol in Pre- and Post-test Control Group Design	100
3.8	The Final Version of Guiding Principle	104
4.1	Adaptation of Constructs and Descriptors for Measuring Creative Thinking through Colouring Activity	111
4.2	Rubrics for Measuring Creative Thinking through Colouring Activity	112
4.3	Instrument for Measuring Creative Thinking through Colouring Activit	113
4.4	Demographic Profile of SMEs	115
4.5	Comments Given by SMEs	119
4.6	Test of Normality for Participants' Pre-test Scores Single-Group Pre- and Post-test Quasi-experiment	130
05-45068327	Test of Normality for Participants' Pre-test Scores Pre- and Post-test Control Group Quasi-experiment	132 <sub>ptbu</sub>
4.8	Comparison of Wilcoxon Signed Ranks Test Results between the Manual Measurement and the Computerised Measurement	138
4.9	Finding for Statistical Comparison between the Manual Measurement and the Computerised Measurement	139
5.1	Data Collected for the Single-group Pre- and Post-test Quasi- experiment	143
5.2	Demographic Profile of Research Participants in School A	144
5.3	Types of Nonparametric Statistical Test Conducted in the First Study	145
5.4	Descriptive Statistics of Data Collected in the First Study (P: poor; F: fair; G: good; V: very good; E: excellent; d: direction of significant; \undersigned: increment, r = effect size)	146
5.5	Comparison of Overall Pre-test and Post-test Average Scores	148
5.6	Comparison of Overall Pre-test and Post-test Fluency Scores	149
5.7	Comparison of Overall Pre-test and Post-test Flexibility Scores	151
5.8	Comparison of Overall Pre-test and Post-test Originality Scores	152





















	5.9	Comparison of Overall Pre-test and Post-test Elaboration Scores	153
	5.10	Data Collected for the Control Group Pre- and Post-test Control Group Quasi-experiment	154
	5.11	Data Collected for the Experimental Group Pre- and Post-test Control Group Quasi-experiment	155
	5.12	Demographic Profile of Research Participants in School B	161
	5.13	Types of Nonparametric Statistical Tests Conducted in the Second Study (Shapiro-Wilk Test & Mann-Whitney U test)	163
	5.14	Types of Nonparametric Statistical Tests Conducted in the Quasi- experiment (Wilcoxon Signed Rank test)	164
	5.15	Descriptive Statistics of Data Collected in the Second Study (C: Control group; E: Experimental group; P: poor; F: fair; G: good; V: very good; E: excellent; d: direction of significance; ↑: increment, r = effect size)	165
	5.16	Comparison of Pre-test Average Scores between Control Group and Experimental Group	169
	5.17	Comparison of Post-test Average Scores between Control Group and Experimental Group	170
05-45068	5.18	Comparison of Overall Pre-test and Post-test score	ptbup 171
	5.19	Comparison of Pre-test and Post-test Average Score in Control Group	173
	5.20	Comparison of Pre-test and Post-test Average Score in the Experimental Group	174
	5.21	Comparison of Pre-test Fluency Scores between the Control Group and the Experimental Group	175
	5.22	Comparison of Post-test Fluency Scores between the Control Group and the Experimental Group	177
	5.23	Comparison of Overall Pre-test and Post-test Fluency Scores	178
	5.24	Comparison of Pre-test and Post-test Fluency Scores in the Control Group	179
	5.25	Comparison of Pre-test and Post-test Fluency Scores in the Experimenta Group	181
	5.26	Comparison of Pre-test Flexibility Scores between the Control Group and the Experimental Group	182
	5.27	Comparison of Post-test Flexibility Scores between the Control Group and the Experimental Group	184





















	5.28	Comparison of Overall Pre-test and Post-test Flexibility Scores	185
	5.29	Comparison of Pre-test and Post-test Flexibility Scores in the Control Group	186
	5.30	Comparison of Pre-test and Post-test Flexibility Scores in the Experimental Group	187
	5.31	Comparison of Pre-test Originality Scores between the Control Group and the Experimental Group	189
	5.32	Comparison of Post-test Originality Scores between the Control Group and the Experimental Group	190
	5.33	Comparison of Overall Pre-test and Post-test Originality Scores	192
	5.34	Comparison of Originality Pre-test and Post-test Score in the Control Group	193
	5.35	Comparison of Pre-test and Post-test Originality Scores in the Experimental Group	194
	5.36	Comparison of Pre-test Elaboration Scores between the Control Group and the Experimental Group	196
05-45068	5.37	Comparison of Post-test Elaboration Scores between the Control Group and the Experimental Group	197 tou
	5.38	Comparison of Overall Pre-test and Post-test Elaboration Score	198
	5.39	Comparison of Pre-test and Post-test Elaboration Scores in the Control Group	200
	5.40	Comparison of Pre-test and Post-test Elaboration Scores in the Experimental Group	201
	5.41	Finding of the Single-Group Pre- and Post-test Quasi-experiment	203
	5.42	Finding of the Pre- and Post-test Control Group Quasi-experiment (Question 1)	204
	5.43	Finding of the Pre- and Post-test Control Group Quasi-experiment (Question 2)	205
	5.44	Finding of the Pre- and Post-test Control Group Quasi-experiment (Question 3)	206
	5.45	Finding of the Pre- and Post-test Control Group Quasi-experiment (Question 4)	207
	5.46	Finding of the Pre- and Post-test Control Group Quasi-experiment (Question 5)	208





















	6.1	Finding of the First Question for Single-Group Pre- and Post-test Quasi- experiment	212
	6.2	Finding of the First Question for Pre- and Post-test Control Group Quasi- experiment	213
	6.3	Finding of the Second Question for Single-Group Pre- and Post-test Quasi-experiment	217
	6.4	Finding of the Second Question for Pre- and Post-test Control Group Quasi-experiment	218
	6.5	Mean, Mode, Median, Range and Standard Deviation for the Fluency Construct	220
	6.6	Finding of the Third Question for Single-Group Pre- and Post-test Quasi- experiment	221
	6.7	Finding of the Third Question for Pre- and Post-test Control Group Quasi-experiment	224
	6.8	Finding of the Forth Question for Single-Group Pre- and Post-test Quasi-experiment	226
05-45068	6.9	Finding of the Forth Question for Pre- and Post-test Control Group  Quasi-experiment  Perpustakaan Tuanku Bainun  Rampus Sultan Abdul Jalil Shah	228 ptbups
	6.10	Finding of the Fifth Question for Single-Group Pre- and Post-test Quasi-experiment	230
	6.11	Finding of the Fifth Question for Pre- and Post-test Control Group Quasi-experiment	234
	6.12	The Final Version of Guiding Principle	245
	6.13	Teacher-led Instruction Using Gagne's Nine Levels of Learning	250





















# LIST OF FIGURES

Figure	No.	age
1.1	HOTS Elements (Adapted from Bahagian Pembangunan Kurikulum, 2014a, p. 3)	5
1.2	Issues and Problem Statement	9
1.3	Key Concepts Related to the Research	22
1.4	Key Concepts and its Relationship	23
1.5	The Final Conceptual Framework	24
1.6	Theoretical Framework	25
1.7	Scope and Position of Creative Thinking Studies in Academia	28
2.1	Conceptual Structure of AR Extracted from Oxford Dictionaries (Oxford University Press, 2018) and Synthesized for Comprehending this Thesis	46
2.2	Simplified Representation of a RV Continuum (Source: Milgram et al., 1995)	47
3.1	Dependant (DV) and independent variables (IV)	ptbups 71
3.2	Step-by-step Procedures for Using the Quiver 3D Colouring App in Classroom Activity	77
3.3	A Set of Tutorial Provided by the App Developer for Using the Quiver 3D Colouring App	79
3.4	Worksheet Required for Using the Quiver 3D Colouring App	81
3.5	Quiver 3D Coloring App can be Downloaded for Free From the Apple App Store or the Google Play Store	82
3.6	A Photo Taken When Observing Child A Working on the Colouring Task on 24 February 2017	82
3.7	A Photo and a Video Were Taken when Observing Child C Completing a Colouring Task on 28 March 2017	83
3.8	School A During Field Trip.	89
3.9	Simple Random Sampling Approach Used in the Quasi-experiment	90
3.10	Representation of Single-Group Pre- and Post-test Design (Vogt et al., 2012)	91



















3.11	Research Protocol Employed in the Single-group Pre- and Post-tests Quasi-experimental Study	91
3.12	During the Pre-test in School A.	93
3.13	During the Treatment in School A	94
3.14	During the Post-test in School A	95
3.15	Samsung Smart Classroom in School B During Field Trip	96
3.16	Simple Random Sampling Approach Used in the Pre- and Post-test Control Group Quasi-experiment	97
3.17	Pre- and Post-test Control Group Design (Vogt et al., 2012)	99
3.18	Research Protocol in Pre- and Post-test Control Group Design	100
3.19	Photos Taken During the Pre-test in School B	101
3.20	Photos Taken During the Intervention in School B	102
3.21	Photos Taken During the Post-test in School B	103
4.1	Manual Measurement Algorithm	109
4.2	Algorithm for Computerised Measurement lil Shah	121 ptbup
4.3	Batch Processing and Terminal Command to Get the Result	122
4.4	Result of the Colouring Worksheet	122
4.5	Identification and Authentication	123
4.6	Homepage View	124
4.7	Output View	124
4.8	Add New Image Page	125
4.9	FAQ Page	126
4.10	About Page	127
4.11	Mobile View of the Software.	128
4.12	Histograms of Pre-test Scores Single-Group Pre- and Post-test Quasi-experiment	130
4.13	Normal Q-Q Plot of Pre-test Scores Single-Group Pre- and Post-test Quasi- experiment	131





















	4.14	Comparison of Box Plots Single-Group Pre- and Post-test Quasi- experiment	131
	4.15	Histograms of Pre-test Scores Pre- and Post-test Control Group Quasi-experiment	133
	4.16	Normal Q-Q Plot of Pre-test Scores Pre- and Post-test Control Group Quasi-experiment	134
	4.17	Comparison of Box Plots Pre- and Post-test Control Group Quasi- experiment	135
	5.1	FAR Creative Colouring Scanner Pre-test Output Data for Single-Group Pre- and Post-test Quasi-experiment	142
	5.2	FAR Creative Colouring Scanner Post-test Output Data for Single-Group Pre- and Post-test Quasi-experiment	142
	5.3	Null and Alternative Hypotheses for Testing the Difference between Overall Pre-test and Post-test Average Scores.	147
	5.4	Null and Alternative Hypotheses for Testing the Difference between Overall Pre-test and Post-test Fluency Scores.	149
05-45068	5.5	Null and Alternative Hypotheses for Testing the Difference between Overall Pre-test and Post-test Flexibility Scores.	150 ptbu
	5.6	Null and Alternative Hypotheses for Testing the Difference between Overall Pre-test and Post-test Originality Scores.	151
	5.7	Null and Alternative Hypotheses for Testing the Difference between Overall Pre-test and Post-test Elaboration Scores.	153
	5.8	FAR Creative Colouring Scanner Pre-test Output Data for Control group in Pre- and Post-test Control Group Quasi-experiment	157
	5.9	FAR Creative Colouring Scanner Post-test Output Data for Control group in Pre- and Post-test Control Group Quasi-experiment	0157
	5.10	FAR Creative Colouring Scanner Pre-test Output Data for Control group in Pre- and Post-test Control Group Quasi-experiment	158
	5.11	FAR Creative Colouring Scanner Post-test Output Data for Experimental group in Pre- and Post-test Control Group Quasi-experiment	159
	5.12	Null and Alternative Hypotheses for Testing the Difference between Ranks of Control Group and Experimental Group in Average Pre-test	168
	5.13	Null and Alternative Hypotheses for Testing the Difference between Ranks of Control Group and Experimental Group in Post-test Average Score	169 e



















5.14	Null and Alternative Hypotheses for Testing the Difference between  Overall Pre-test and Post-test	71
5.15	Null and Alternative Hypotheses for Testing the Difference between Pre-1 test and Post-test Average Scores in Control Group	72
5.16	Null and Alternative Hypotheses for Testing the Difference between Pre-1 test and Post-test Average Score in Experimental Group	73
5.17	Null and Alternative Hypotheses for Testing the Difference between 1 Ranks of the Control Group and the Experimental Group in Pre-test Fluency Scores	75
5.18	Null and Alternative Hypotheses for Testing the Difference between 1 Ranks of Control Group and Experimental Group in Post-test Fluency Scores	76
5.19	Null and Alternative Hypotheses for Testing the Difference between Overall Pre-test and Post-test Fluency Scores	.77
5.20	Null and Alternative Hypotheses for Testing the Difference between Pre-1 test and Post-test Fluency Scores in the Control Group	79
5.21	Null and Alternative Hypotheses for Testing the Difference between Pre-1 test and Post-test Fluency Scores in the Experimental Group	.80 ptb
5.22		82
5.23	Null and Alternative Hypotheses for Testing the Difference between 1 Ranks of Control Group and Experimental Group in Post-test Flexibility Scores	.83
5.24	Null and Alternative Hypotheses for Testing the Difference between Overall Pre-test and Post-test Flexibility Scores	84
5.25	Null and Alternative Hypotheses for Testing the Difference between Pre-1 test and Post-test Flexibility Scores in the Control Group	86
5.26	Null and Alternative Hypotheses for Testing the Difference between Pre-1 test and Post-test Flexibility Scores in the Experimental Group	87
5.27	Null and Alternative Hypotheses for Testing the Difference between 1 Ranks of The Control Group and The Experimental Group in Pre-test Originality Scores	88
5.28	Null and Alternative Hypotheses for Testing the Difference between 1 Ranks of Control Group and Experimental Group in Post-test Originality Scores	90





















	5.29	Null and Alternative Hypotheses for Testing the Difference between Overall Pre-test and Post-test Originality Scores	191
	5.30	Null and Alternative Hypotheses for Testing the Difference between Pretest and Post-test Originality Scores in The Control Group	192
	5.31	Null and Alternative Hypotheses for Testing the Difference between Pretest and Post-test Originality Scores in The Experimental Group	193
	5.32	Null and Alternative Hypotheses for Testing the Difference between Ranks of Control Group and Experimental Group in Pre-test Elaboration Scores	195 n
	5.33	Null and Alternative Hypotheses for Testing the Difference between Ranks of the Control Group and the Experimental Group in Post-tes Elaboration Scores	196 t
	5.34	Null and Alternative Hypotheses for Testing the Difference between Overall Elaboration Pre-test and Post-test Score	198
	5.35	Null and Alternative Hypotheses for Testing the Difference between Pretest and Post-test Elaboration Scores in the Control Group	199
05-4506	5.36	Null and Alternative Hypotheses for Testing the Difference between Pretest and Post-test Elaboration Scores in the Experimental Group	200 ptbups
03-43000	6.1	Relationship between the Research Objectives and Research Questions	210
	6.2	Quiver Colouring App (Billinghurst et al., 2015)	214
	6.3	The Guiding Principle Diagram	242



















### LIST OF ABREVIATIONS

AR Augmented Reality

**DSKP** National Standard Curriculum for Preschool

**EPRD Education Planning and Research Department** 

**FAR** Fast, Accurate and Reliable

**HOTs** Higher Order Thinking Skills

**ICT** Information and Communication Technology

JPN **State Education Department** 

**KBSM** New Secondary School Curriculum

**KBSR New Primary School Curriculum** 

05-45068**KSSR** Revised Primary School Standard-based Curriculum

**MOE** Ministry of Education Malaysia

**SPSS** Statistical Package for the Social Science

**SME** Subject Matter Expert

**TTCT** Torrance Tests of Creative Thinking

**UPSI** Sultan Idris Education University, Malaysia

3D Three Dimension



















### LIST OF APPENDICES

- Α Milestones Perkembangan Kreativiti dan Estetika Kanak-kanak (Aminah Ayob et al., 2013, p.287 & p.288)
- В Child Development Milestones
- C Four to Six Years Abilities
- D Application To Use Quiver App
- E Electronic Databases Search Creative Thinking, Preschool and Colouring
- F Revised Primary School Standard-Based Curriculum or Kurikulum Standard Prasekolah Kebangsaan (KSSR) (Bahagian Pembangunan Kurikulum, 2016a, P. 1 - P. 13)
- G Recommended Activity for Art Education Subject to Embed Creative Thinking Skills (Pusat Perkembangan Kurikulum, 2002, P. 99 – P. 101) 05-4506832
- Electronic Databases Search for AR, Creative Thinking, Preschool and Η Colouring Search Term
- I Electronic Databases Search for Measurement, Creative Thinking, AR and Colouring Search Term
- J Electronic Databases Search for TTCT Search Term
- K Electronic Databases Search Effect, Colouring, Creative Thinking, TTCT Constructs and Preschool
- L Student Status Confirmation Letter
- M Approval Granted by the Ministry of Education to Conduct Research in Preschools
- N Application and Approval Granted by Kelantan State Education Department to Conduct Research in National School
- 0 Colouring Marking Checklist
- P Descriptive Statistics and Inferential Statistics
- First Version of Validity Instrument Assessment Form Q
- R Final Version of Validity Instrument Assessment Form





















- S Normality Test Normality Test for The Single-Group Pre- and Post-Test Quasi-experiment
- T Normality Test for The Pre- and Post-Test Control Group Quasiexperiment
- U Pre-Test Data Collected in the Single-Group Pre- and Post-Test Quasiexperiment
- V Statistical Comparison between Manual and Computerised Measurement
- W Pre-Test Data Collected in The Pre- and Post-Test Control Group Quasiexperiment
- X Certificate of Proofreading
- Y Certificate of Intellectual Property Copyright
- Z Certificate of Malaysia Technology Expo 2019 MTE Gold Award





























### **CHAPTER 1**

### INTRODUCTION











This research aims to examine whether or not an augmented reality (AR) colouring activity that involves the use of a mobile app affects preschool children's creative thinking. In the course of achieving research objectives, the thesis offers preschool teachers a set of guiding principles for using AR technology in teaching and learning. According to Fisher and Frey (2015), it is difficult to know exactly what students are getting after the lesson, unless the teacher checks for understanding. Checking for understanding is a formative assessment and it plays a central role in outcome-based education (Baird, Andrich, Hopfenbeck, & Stobart, 2017), affording teachers to keep improving teaching and learning in future lessons in order to accomplish specific learning outcomes. Align with this proposition, the research was grounded on four teaching and learning steps proposed by Fisher and Frey (2015): 1) presenting

















materials, lessons or learning opportunities; 2) checking for understanding; 3) providing student feedback and; 4) planning instruction based on students' misconception. These steps were followed when conducting two quasi-experiments in two national preschools located in Kelantan, Malaysia. The results of the study, as shown in Section 4.5 in Chapter 4, were meant for developing an instrument for measuring creative thinking among preschool children.

This thesis consists of six chapters. The first chapter discusses an overview of the research, including its background, problem statements, aims, research objectives, specific research questions and hypotheses. The second chapter provides the literature review of studies on the use of AR applications in colouring activities, particularly for improving and assessing creativity. The third chapter reports the methodology, research design and the development of a set of guiding principles. The fourth chapter depicts the design, development and validation of instruments to measure the level of creative thinking among preschool children. The fifth chapter juxtaposes the findings of both quasi-experiments and discusses how hypotheses formulated from research questions were tested to form research answers. The last chapter summarizes all conclusive propositions, while juxtaposing the overall contribution and limitations made throughout the research.

#### 1.2 **Background of the Research**

The origin of this research came largely from the researcher's seven years of teaching experiences in two primary schools and eight years of experiences as a lecturer in two





















matriculation colleges in Malaysia. Dealing with students of a wide range between five to 18 years old directly and indirectly offered this research an insight that individuals learn in different ways and develop their thinking skills in multiple ways (Gagné, 1972). The idea of pursuing a doctorate degree in Multimedia Education at the Faculty of Art, Computing and Creative Industry, Sultan Idris Education University, Malaysia (UPSI) with this research topic was inspired by the increasing use of ICT among school teachers to facilitate teaching and learning process. In a nutshell, this research attempted to put an idea of ICT application into practice, and then examined its effectiveness toward creative thinking through a quasi-experimental study on preschool children in Malaysia. The fundamental assumption made in this research was that using AR app in teaching and learning activities can increase the level of creative thinking among preschool children.











This research used a form of multimedia application called AR to help the teaching and learning process focus on colouring activities (Billinghurst, Clark, & Lee, 2015; Santos et al., 2016). AR was selected because it was seen as a multimedia application that can combine elements such as image, audio and animation, affording AR to receive positive feedback among educators and children (Di Serio, Ibáñez, & Kloos, 2013; Westerfield, Mitrovic, & Billinghurst, 2015). Moreover, AR can show virtual three dimensional (3D) objects superimposed over the real world (Billinghurst et al., 2015; Santos et al., 2016). For instance, an AR colouring app called Quiver allows users to point their mobile device to a colouring worksheet in order to visualize an animated 3D figure with their choice of colours (Billinghurst et al., 2015). In particular, the animation element in AR made significant contribution in various subject matters





















of education for the past decades (Kogilathah, Ahmad Zamzuri M.A, & Tan, 2014). The animation also can yield positive effects on the creative thinking ability of targeted learners (Billinghurst et al., 2015; Diegmann, Schmidt-Kraepelin, Eynden, & Basten, 2015; Kerawalla, Luckin, Seljeflot, & Woolard, 2006; Santos et al., 2016).

Two studies were found directly related to colouring and creative thinking. In a joint-research between Disney Research and two universities, (Zünd et al., 2015) attempted to use AR colouring book to engage children for boosting imagination and creativity. Zünd et al. (2015) coined the idea of "augmented creativity" and claimed that their app can enhance real-world interaction, discovery, exploration, and imagination. In a study conducted by Feng, Yang and Xiao (2017), an AR app called MagicToon was used to facilitate drawing and colouring. Feng et al. (2017) revealed 05-45068 that MagicToon can better stimulate children's creativity compared to other similar apps.

Human being with higher order thinking skills (HOTs) are able to apply knowledge, skills and values in making reasoning and reflection to solve problem, make decision innovatively and creatively (Bahagian Pembangunan Kurikulum, 2014a). According to Bahagian Pembangunan Kurikulum (2014a), HOTs refers to a collection of four skills, i.e. applying, analyzing, evaluating and creating, in order to cultivate critical thinking and creative thinking among pupils or students (Bahagian Pembangunan Kurikulum, 2014b). Critical thinking and creative thinking were introduced in the Malaysia National Curriculum in 1994 through New Primary School Curriculum or Kurikulum Bersepadu Sekolah Rendah (KBSR) and New Secondary School Curriculum or Kurikulum Bersepadu Sekolah Menengah (KBSM) (Bahagian











Pembangunan Kurikulum, 2014c). The Ministry of Education Malaysia (MOE) reemphasised critical thinking and creative thinking through a revised Primary School Standard-based Curriculum or Kurikulum Standard Sekolah Rendah (KSSR) in 2011 (Bahagian Pembangunan Kurikulum, 2014c) due to the lack of intensive implementation (Pusat Perkembangan Kurikulum, 2002). Then HOTs were reintroduced in KSSR again in 2013 (Ministry of Education Malaysia, 2013). All the HOTs elements in revised version of Bloom's taxonomy, as shown in Figure 1.1 was embedded into the learning standard of preschool curriculum, and the embed of HOTs elements was sustained until post-secondary level (Ministry of Education Malaysia, 2013).

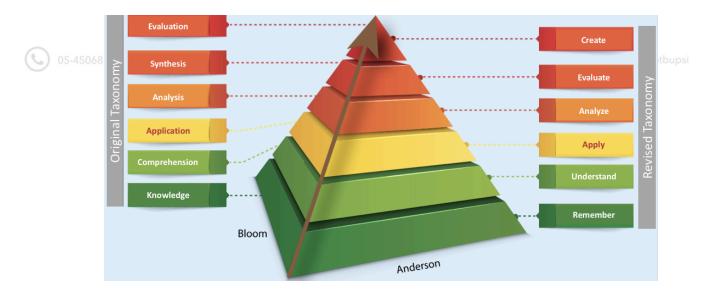


Figure 1.1. HOTS Elements (Adapted from Bahagian Pembangunan Kurikulum, 2014a, p. 3)

Revised version of Bloom's taxonomy for teaching, learning and assessment demonstrated that these are six classifications of cognitive processes when learners work with knowledge, they are: 1) remember; 2) understand; 3) apply; 4) analyse; 5) evaluate; and 6) create. In the first taxonomy, learners can recall facts and basic





















concepts by defining and remembering them. The second taxonomy is understand which means learners are capable to explain ideas and concepts by classifying and describing them. In the third taxonomy, learners use information in new situations by applying, implementing, demonstrating and interpreting them. In the fourth taxonomy, learners can analyse by draw connections among ideas, differentiating and examining them. In the fifth taxonomy, which is learners can evaluate which is capable to justify the stands or decisions by arguing and critiquing them. The last element in the taxonomy is create, which is learners can produce new or novel work by designing and developing them (Anderson, Krathwohl, & Bloom, 2001). The revised version of Bloom's taxonomy shows that learning is far beyond than remembering and understanding the concepts. Learners can be the innovator of generating new concepts and ideas. In this sense, the learning contents of particular subject matters and the associated teaching and learning approaches deployed by teachers in the classroom should match the cognition level of pupils or students, allowing the students to remember, understand, apply, analyse, evaluate and create.

When teachers construct questions to elicit learning performance, the elements of HOTs ought to be taken into consideration. However, only a small number of students can answer questions creatively, i.e. thinking out of the box, offering imaginative yet wrong answers that go beyond normality (Eastaway, 2013). According to Eastaway (2013), human beings tend to find logically right answer from the children instead of embracing creatively wrong answers. In this sense, children's creativity was killed by responses like "No, that would never work". Therefore, creative thinking must be taught in the early childhood to cultivate HOTs because it is feasible to teach children





















to think creatively at this stage and this can be done in a variety of ways (Torrance, 1972a).

One suitable way to teach creative thinking in nowadays scenario is using multimedia in education. The use of multimedia in education may lead to innovative teaching and learning processes. As highlighted in the Education Development Master Plan 2013-2025 (Ministry of Education Malaysia, 2013), teachers were also encouraged to use information communication technology (ICT), especially when preparing and providing multimedia module for use inside and outside the classroom in order to enhance the quality of teaching and learning (Ministry of Education Malaysia, 2017).

Creativity was defined by Torrance (1977) as the contribution of original ideas using a different point of view, or a new way of looking at problems. Torrance (1977) insisted that creativity can also be defined as a successful step in the production of something new or original product, the results of the process embodied in an invention, a scientific theory, an improved product, a literary work, a musical composition, a new design, recombining ideas or the like. Meanwhile, creative thinking is a necessity of learning environment in the 21st Century (Partnership for 21st Century Learning, 2015). Human creativity has become a defining feature of economic life, in which the creativity must be nurtured and nourished since childhood (Peck, 2005; Torrance, 1972a). After conducting the teaching and learning session in subject matters like art, music, and physical education, the success or failure of the teaching and learning would be depending on children's capability to think creatively during the intervention (Torrance, 1972a). The capability can be measured using four criteria: fluency, flexibility, originality and elaboration (Torrance, 1972a). Even though creativity could





















be something that people easily identify without referring to any guiding definition, the level of creativity among children can still be differentiated as either more creative or less creative, when specific criteria are referred in the judgment (Amabile, 1983). According to Amabile (1983), there must be a distinction between creative performance and ordinary performance. The results are likely to influence the generation and development of creative individuals (Amabile, Conti, Coon, Lazenby, & Herron, 1996), as a resource for communities (Peck, 2005). This research adopted the measurement of creative thinking through the criteria introduced by Torrance (1972a) to determine the effects of AR colouring app upon preschool children's creative thinking.

MOE consistent with the effort of re-engineering Malaysian education with ICT. Integrating technology like AR in teaching and learning has been set as one of the os-4506 initiatives taken by the government in building a solid foundation for revamping Malaysia education system (Ministry of Education Malaysia, 2013). According to the Education Development Master Plan, all the teaching and learning activities conducted in preschool settings must follow the preschool syllabus with the aid of ICT. However, the results of a study conducted by Sandra, Abu Bakar and Norlidah (2013) in Malaysia, showed that teachers in the national preschools were positive in their attitudes toward employing ICT, although these teachers were still lacking of actual practices.

#### 1.3 **Problem Statement**

In the formation of the problem statement of this study, four main issues were identified: 1) the lack of research in creative thinking in relation to colouring; 2) the











limited resources in art and play materials; 3) the lack of studies demonstrated how to measure the creative thinking of application or software in the market; and 4) the lack of standard assessment tools for measuring creative thinking specifically in colouring activity (see Figure 1.2). These issues directed the phenomenon of regarding colouring activity as a filler of teaching and learning, without taking the opportunity to improve children's creative thinking in preschool education.

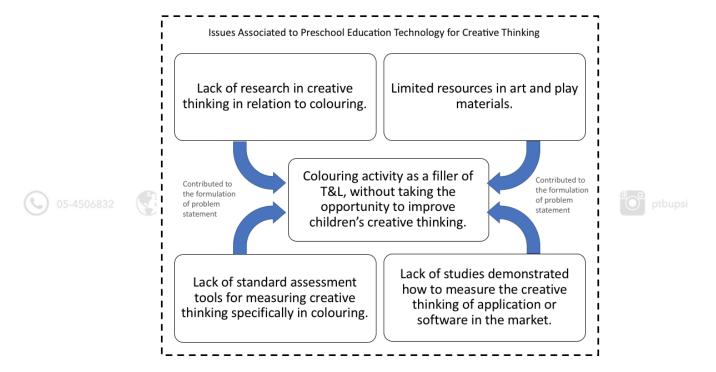


Figure 1.2. Issues and Problem Statement

The first issue was the lack of empirical research studies in creative thinking in the relation to AR and colouring activities (refer to Section 2.3.2 in Chapter 2 for further discussion). Twelve electronic databases were searched to examine the presence of academic publications associated to colouring and creative thinking among preschool children, especially in education field, information technology and social science (refer to Table 2.1 in Chapter 2).



















The second issue was the lack of resources in art and play materials. These resources, e.g. clay, sand pit, educational toys, etc, are normally supplied upon the establishment of a preschool. However, once the preschool runs out of those materials, the school administrators are not able to restock, forcing teachers to conduct classes without art and play materials, hence the ease of chalk-and-talk teaching approach. In addition, preschool teachers are lacking of references to design creative activities in the classroom for the children (Azli Ariffin & Roselan Baki, 2014). In such conditions, the use of ICT in the classroom was found motivating, adding enjoyment in children learning (Sheridan & Samuelsson, 2003), despite certain usage of ICT in preschool failed to show explicit positive effect on children's academic performance (Sharifah Nor Puteh & Kamarul Azman Abd Salam, 2011). To augment the benefit of ICT in preschool settings, teachers have to be creative when applying specific ICT in classroom settings (Sandra Rahman et al., 2013; Sharifah Nor Puteh & Kamarul Azman Abd Salam, 2011). Therefore, this research intended to fill in this gap by developing a set of guiding principles and teacher-led instruction for implementing ICT, specifically AR app in teaching and learning process.

The third issue was the lack of research-based measuring instruments for creative thinking among preschool children (refer to Section 2.4 in Chapter 2 for further discussion). As a result, it was difficult, if not impossible to reveal the effects of AR apps in the consumer market. The use of AR app such as MagicBook, CCDU AR, CityViewAR, Living Sasquatch and the like was found having the potential to change how human interact with digital contents positively (Billinghurst et al., 2015). From early studies conducted in the 1960's until the widespread availability around the 2010's, there had been steady progress towards the goal of combining real and virtual





















worlds seamlessly (Billinghurst et al., 2015). Nevertheless, there was still a lack of academic literature presenting and justifying sufficiently the educational potential and affordances of AR technology in primary education (Fotaris, Pellas, Kazanidis, & Smith, 2017). Hence empirical research was necessary to examine different facets of AR applications for preschool and primary education. All above-mentioned studies which were related to AR app should base on sound theoretical frameworks or reliable evaluation methods to further establish the pedagogy of AR-based applications in different subject maters. Studies associated to five types of mobile app on the market place claimed that the use of mobile apps can enhance creative thinking, specifically story-making app (Kucirkova, Messer, Sheehy, & Fernández Panadero, 2014), AR colouring app (Magnenat et al., 2015), painting and colouring app (Tokuhisa, Kamiyama, & Tokiwa, 2015), puppetry app (Wohlwend, 2015), drawing app (Yadav & Chakraborty, 2017). Nonetheless, none of these studies demonstrated how to measure creative thinking among children to prove the effects of those apps.

The last issue was related to the third, as there was a lack of standard assessment tools for measuring creative thinking, specifically in colouring activities for preschool children (refer to Section 2.4 in Chapter 2 for further discussion). When comparing to most creative thinking assessment instruments, Torrance Tests of Creative Thinking (TTCT) was found to be the most widely used instrument (Bahar & Ozturk, 2018; Rababah, 2018; Said-Metwaly, Fernández-Castilla, Kyndt, & Van den Noortgate, 2018). However, previous research shown that different activity would contribute to the development of creative thinking on different constructs of TTCT (refer to Section 2.4 in Chapter 2). Thus, this research was conducted to examine the effects of AR colouring activity towards four constructs of creative thinking among preschool children.











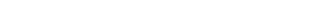








All of the four issues mentioned above contributed to the formulation of problem statement in this research. Due to the lack of empirical research studies, resources, measurement methods and assessment tools for creative thinking in AR colouring activities among preschool children, colouring activities were conducted as fillers of teaching and learning, rather than being the opportunity to improve children's creative thinking (refer to Section 2.2.2 in Chapter 2). With reference to the issues elaborated above, this research was conducted to examine the effects of AR colouring activity towards creative thinking among preschool children. An off-the-shelf AR app was used in a colouring activity, while a rubric with a bespoke software was developed specifically for the colouring activity to measure the level of creative thinking. The AR colouring mobile app allows users interact actively with virtual and physical objects 05-45068 while engaging in colouring activities. Sultan Abdul Jalil Shah



**Research Aim and Objectives** 

1.4

This research aimed to determine the effects of AR colouring activity towards creative thinking among preschool children. A provisional guiding principle was developed with reference to the conceptual framework (refer to Section 1.6) and the theoretical framework of this research (refer to Section 1.7). An instrument was prepared for measuring the level of creative thinking in order to carry out two quasi-experiment studies with preschool children. Five research objectives were set to achieve the research aim:



















- 1. To compare the level of creative thinking before and after using AR colouring mobile app.
- 2. To compare the use of multiple colours among preschool children before and after using AR colouring mobile app.
- 3. To compare the use of multiple colouring techniques among preschool children before and after using AR colouring mobile app.
- 4. To compare the attempt of adding new object in colouring activity among preschool children before and after using AR colouring mobile app.
- 5. To compare the choice of colour weight in colouring activity among preschool children before and after using AR colouring mobile app.

# 05-450681.5 Research Questions and Hypotheses boul Jalil Shah



Five research questions were built based on the research objectives. These objectives were operationalised into the following research questions:

- 1. Is there a significant difference of preschool children's creative thinking before and after using AR colouring mobile app?
- Is there a significant difference in the use of multiple colours among preschool children before and after using AR colouring mobile app?
- Is there a significant difference in the use of multiple colouring techniques among preschool children before and after using AR colouring mobile app?
- Is there a significant difference in the attempt of adding new object in colouring activity among preschool children before and after using AR colouring mobile app?



















Is there a significant difference in the choice of colour weight in colouring activity among preschool children before and after using AR colouring mobile app?

Five null hypotheses and five alternative hypotheses were formulated for conducting the first quasi-experiment, in which statistical tests were run in search for research answers, as Table 1.1.

























Table 1.1 Hypotheses of the Single-Group Pre- and Post-test Quasi-experiment

_	<b>Objective</b> Question		•	Hypothesis			
	1.	To compare the level of creative thinking	Is there a significant difference of preschool	1.	H <sub>0</sub> : There was no significant difference between the overall pre-		
		before and after using AR colouring mobile app.	children's creative thinking before and after playing AR colouring mobile app?	2.	test and post-test total scores. H <sub>1</sub> : There was a significant difference between the overall pretest and post-test total scores.		
-	2.	To compare the use of multiple colours among preschool	Is there a significant difference in the use of multiple colours among	3.	H <sub>0</sub> : There was no significant difference between the overall pretest and post-test fluency scores.		
		children before and after using AR colouring mobile app.	preschool children before and after using AR colouring mobile app?	4.	H <sub>1</sub> : There was a significant difference between the overall pretest and post-test fluency scores.		
-	3.	To compare the use of multiple colouring techniques among	Is there a significant difference in the use of multiple colouring	5.	H <sub>0</sub> : There was no significant difference between the overall pretest and post-test flexibility scores.		
		preschool children before and after using AR colouring mobile app.	techniques among preschool children before and after using AR colouring mobile app?	6.	H <sub>1</sub> : There was a significant difference between the overall pretest and post-test flexibility scores.		
05-450683	4.	To compare the attempt of adding new object in colouring activity among	Is there a significant difference in the attempt of adding new object in colouring activity among	Ba <del>y</del> nun I Jalil Sh	H <sub>0</sub> : There was no significant difference between the overall pretest and post-test originality scores.		
		preschool children before and after using AR colouring mobile app.	preschool children before and after using AR colouring mobile app?	8.	H <sub>1</sub> : There was a significant difference between the overall pretest and post-test originality scores.		
-	5.	To compare the choice of colour weight in colouring activity among	Is there a significant difference in the choice of colour weight in colouring activity among	9.	H <sub>0</sub> : There was no significant difference between the overall pretest and post-test elaboration scores.		
		preschool children before and after using AR colouring mobile app.	preschool children before and after using AR colouring mobile app?	10.	H <sub>1</sub> : There was a significant difference between the overall pretest and post-test elaboration scores.		

The second quasi-experiment, 50 null hypotheses and 50 alternative hypotheses were formulated for statistical testing in search for answers, as Table 1.2.











Table 1.2 Hypotheses of the Pre- and Post-test Control Group Quasi-experiment

	Objective	Question		Hypothesis
of c befo usir	compare the level reative thinking ore and after ag AR colouring oile app.	Is there a significant difference of preschool children's creative thinking before and after playing AR colouring mobile app?	2.	H <sub>0</sub> : There was no significant difference between the overall pretest ranks of the control group and the experimental group.  H <sub>1</sub> : There was a significant difference between the overall pretest ranks of the control group and the experimental group.
			3.	H <sub>0</sub> : There was no significant difference between the overall posttest ranks of the control group and
			4.	the experimental group.  H <sub>1</sub> : There was a significant difference between the overall posttest ranks of the control group and the experimental group.
			5.	H <sub>0</sub> : There was no significant difference between the overall pretest and post-test.
				H <sub>1</sub> : There was a significant difference between the overall pretent and part test
			7.	H <sub>0</sub> : There was no significant difference between the overall pretest and post-test in the control
			8.	group.  H <sub>1</sub> : There was a significant difference between the overall pretest and post-test in the control group.
			9.	H <sub>0</sub> : There was no significant difference between the overall pretest and post-test in the
			10.	experimental group.  H <sub>1</sub> : There was a significant

(continued)









difference between the overall pre-

test and post-test in the experimental group



## Hypotheses of the Pre- and Post-test Control Group Quasi-experiment

	Objective	Question		Hypothesis
•	To compare the use of multiple colours among preschool children before and after using AR colouring mobile app.	Is there a significant difference in the use of multiple colours among preschool children before and after using AR colouring mobile app?		H <sub>0</sub> : There was no significant difference in pre-test fluency scores between the control group and the experimental group.  H <sub>1</sub> : There was a significant difference in pre-test fluency scores between the control group and the experimental group.
			13.	H <sub>0</sub> : There was no significant difference in overall post-test fluency scores between the control group and the experimental group.
			14.	H <sub>1</sub> : There was a significant difference in overall post-test fluency scores between the control group and the experimental group.
	pustaka.upsi.edu			H <sub>0</sub> : There was no significant difference between the overall pre-test and post-test fluency scores.
				H <sub>1</sub> : There was a significant difference between the overall pre-test and post-test fluency scores.
			17.	H <sub>0</sub> : There was no significant difference between the overall pre-test and post-test fluency scores in control group.
			18.	scores in control group.  H <sub>1</sub> : There was a significant difference between the overall pre-test and post-test fluency scores in control group.
			19.	H <sub>0</sub> : There was no significant difference between the overall pre-test and post-test fluency scores in the experimental group.
			20.	H <sub>1</sub> : There was a significant difference between the overall pre-test and post-test fluency

(continued)











## Hypotheses of the Pre- and Post-test Control Group Quasi-experiment

	Objective	Question		Hypothesis	_
3.	To compare the use of multiple colouring techniques among preschool children	Is there a significant difference in the use of multiple colouring techniques among preschool children	21.	H <sub>0</sub> : There was no significant difference in pre-test flexibility scores between the control group and the experimental group.	
	before and after using AR colouring mobile app.	before and after using AR colouring mobile app?	22.	H <sub>1</sub> : There was a significant difference in pre-test flexibility scores between the control group and the experimental group.	
			23.	H <sub>0</sub> : There was no significant difference in overall post-test flexibility scores between the control group and the	_
			24.	experimental group. H <sub>1</sub> : There was a significant difference in overall post-test fluency scores between the control group and the experimental group.	
05-4506832	pustaka.upsi.edu.			H <sub>0</sub> : There was no significant difference between the overall pre-test and post-test flexibility scores.  H <sub>1</sub> : There was a significant difference between the overall pre-test and post-test flexibility scores.	ptbu
				H <sub>0</sub> : There was no significant difference between the overall pre-test and post-test flexibility scores in the control group.	_
			28.	H <sub>1</sub> : There was a significant difference between the overall pre-test and post-test flexibility scores in the control group.	
			29.	H <sub>0</sub> : There was no significant difference between the overall pre-test and post-test flexibility scores in the experimental group.	_
			30.	H <sub>1</sub> : There was a significant difference between the overall pre-test and post-test flexibility scores in the experimental group.	

(continued)











## Hypotheses of the Pre- and Post-test Control Group Quasi-experiment

71	V	1	~	1	
	Objective	Question		Hypothesis	_
4.	To compare the attempt of adding new object in colouring activity among preschool children before and after using AR colouring mobile	Is there a significant difference in the attempt of adding new object in colouring activity among preschool children before and after using AR colouring mobile app?		H <sub>0</sub> : There was no significant difference in pre-test originality scores between the control group and the experimental group.  H <sub>1</sub> : There was a significant difference in pre-test originality scores between the control group and the experimental group.	
	арр.			H <sub>0</sub> : There was no significant difference in overall post-test originality scores between the control group and the experimental group. H <sub>1</sub> : There was a significant	_
			34.	difference in overall post-test originality scores between the control group and the experimental group.	
	pustaka.upsi.edu			H <sub>0</sub> : There was no significant difference between the overall pre-test and post-test originality scores.	pt
				H <sub>1</sub> : There was a significant difference between the overall pre-test and post-test originality scores.	
				H <sub>0</sub> : There was no significant difference between the overall pre-test and post-test originality scores in the control group.	_
			38.	H <sub>1</sub> : There was a significant difference between the overall pre-test and post-test originality scores in the control group.	
			39.	H <sub>0</sub> : There was no significant difference between the overall pre-test and post-test originality scores in the experimental group.	_
			40.	H <sub>1</sub> : There was a significant difference between the overall pre-test and post-test originality	

(continued)









scores in the experimental group.



## Hypotheses of the Pre- and Post-test Control Group Quasi-experiment

	Objective	Question		Hypothesis
5.	To compare the choice of colour weight in colouring activity among preschool children before and after using AR colouring mobile app.	Is there a significant difference in the choice of colour weight in colouring activity among preschool children before and after using AR colouring mobile app?		H <sub>0</sub> : There was no significant difference in pre-test elaboration scores between the control group and the experimental group.  H <sub>1</sub> : There was a significant difference in pre-test elaboration scores between the control group and the experimental group.
				H <sub>0</sub> : There was no significant difference in overall post-test elaboration scores between the control group and the experimental group.  H <sub>1</sub> : There was a significant difference in overall post-test elaboration scores between the control group and the experimental group.
	pustaka.upsi.edu			H <sub>0</sub> : There was no significant difference between the overall pre-test and post-test elaboration scores.  H <sub>1</sub> : There was a significant difference between the overall pre-test and post-test elaboration scores.
				H <sub>0</sub> : There was no significant difference between the overall pre-test and post-test elaboration scores in the control group.  H <sub>1</sub> : There was a significant difference between the overall pre-test and post-test elaboration scores in the control group.
			-10	H <sub>0</sub> : There was no significant









pre-test and post-test elaboration scores in the experimental group.

50. H<sub>1</sub>: There was a significant difference between the overall pre-test and post-test elaboration scores in the experimental group.













#### 1.6 **Conceptual Framework**

According to the Oxford Dictionaries Online (2018), a "framework" can be defined as a basic structure underlying a system, concept, or text. Frameworks can come in several names such as conceptual framework, practical framework and theoretical framework with difference shapes, sizes and perspectives (Bordage, 2009). Different frameworks were used by the researcher to facilitate this research, including the presentation of concepts, methods and findings. In general, a conceptual framework provides an idea of how well the variables are connected together according to the research needs (Ivey, 2015). In this research, a conceptual framework was developed through a three-step approach: a) list down all the key concepts related to the research; b) make a relationship among all the concepts through a relationship diagram; and c) synthesize



of the relationship diagram to produce and fine tune a conceptual framework.



In the first step, all the key concepts related to the research were identified and listed down in each sticky note (see Figure 1.3). The words included augmented reality, teaching aid, guiding principle, preschool children, preschool teacher, Malaysia school, theories, creativity, creative thinking, technology, example, colouring, TTCT, fluency, flexibility, originality, elaboration, app, gender, age, measurement, manual and computerize.











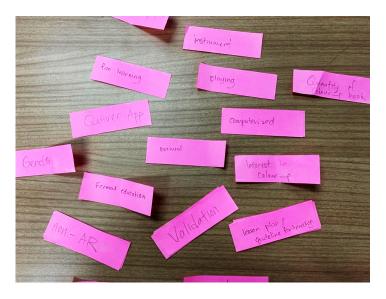


Figure 1.3. Key Concepts Related to the Research

After that, every relationship between two concepts was defined using a verb to make it logical, rational and meaningful. The second step involved producing drafts of the framework based on the preliminary structure, in the course of creating a proper diagram of the conceptual framework. Figure 1.4 is a draft of the conceptual framework that depicted all the key concepts and relationships between those concepts. In final step, the draft of conceptual framework was compacted and extracted to form a synthesized and finalized framework. Figure 1.5 showed the final version of conceptual framework, built for this research in order to visualize how the four constructs may be potentially interrelated.











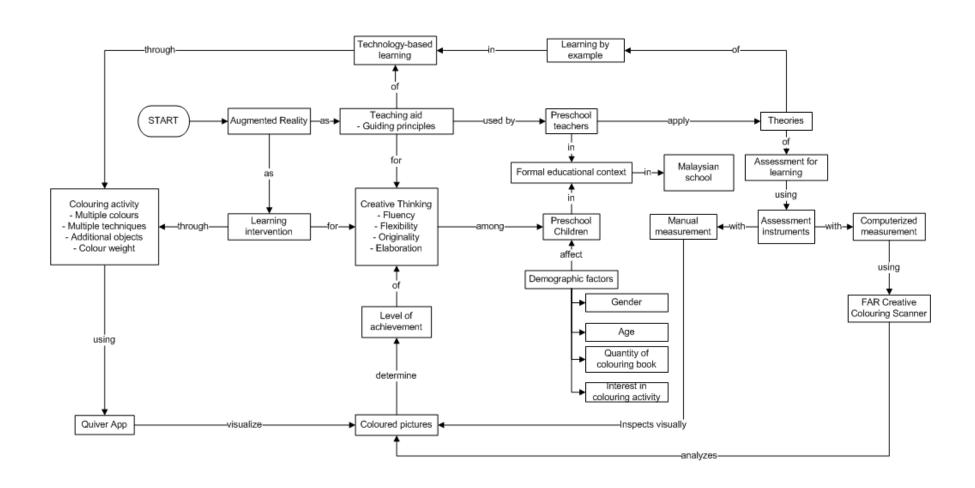


Figure 1.4. Key Concepts and its Relationship



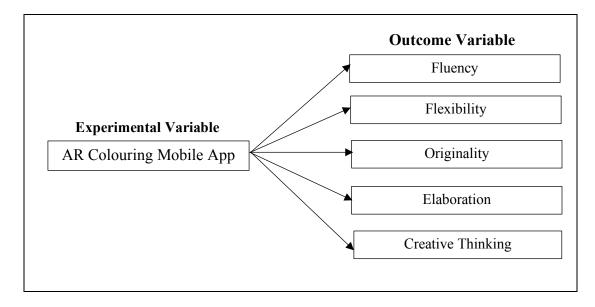


Figure 1.5. The Final Conceptual Framework

or experimental variable, tested to examine the effects of AR colouring mobile app towards creative thinking, specifically in fluency, flexibility, originality and elaboration. In this sense, creative thinking, fluency, flexibility, originality and elaboration were the dependent variables or outcome variables in the study. The framework was developed according to pairwise comparisons that involve the relationships between AR colouring mobile app with creative thinking.

As shown in Figure 1.5, AR colouring mobile app was the independent variable

#### 1.7 **Theoretical Framework**

A theoretical framework refers to the theory used to guide the research (Imenda, 2014). As the evaluation of AR is essential towards achieving high level of creative











thinking in school, Gagne's nine events of instruction and TTCT was chosen to offer an explanation and guidance toward answer the research problem (see Figure 1.6).

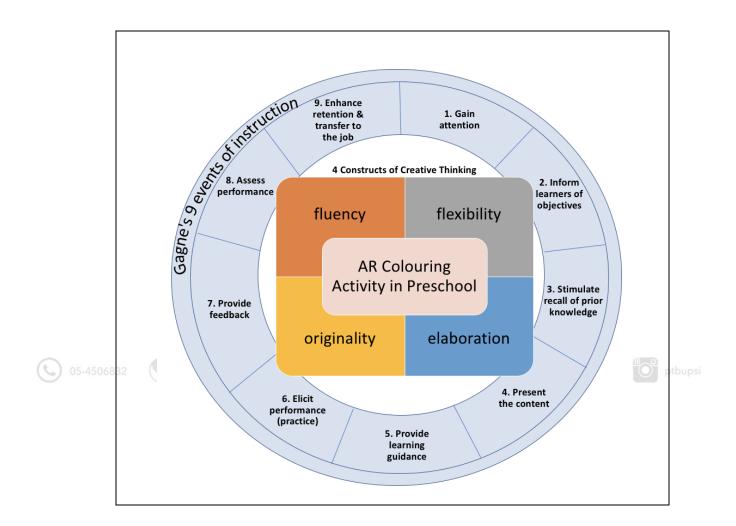


Figure 1.6. Theoretical Framework

Grounded on cognitivism theory of learning, Gagne's nine events of instruction was an instructional strategy that permits one to predict the effects of specific instructional conditions on a learner's cognitive processing and the resulting learned capabilities (Smith & Ragan, 1996). Gagné (1985) described the nature of an instructional strategy as an attempt to relate in terms of internal and external conditions. Internal conditions included motivational states and previous knowledge





















that was stored in long-term memory accessible for new learning, conversely an external conditions, refers to the set of events collectively called instruction.

Gagne's nine events of instruction, conceived as a set of stimuli which give support to internal learning processes. The model helps trainers, educators and instructional designer to design their teaching and learning sessions properly. It also provide guidance for an effective and systematic learning process. These nine events begin with: 1) gain attention; 2) inform learners of objective; 3) stimulate recall of prior knowledge; 4) present the content; 5) provide learning guidance; 6) elicit performance or practise; 7) provide feedback; 8) assess performance; and 9) enhance retention and transfer.

The nine events of instruction can be divided into three segments: 1) preparation; 2) instruction and practice; and 3) assessment and transfer. In the first segment (preparation) consist of three events: 1) gain attention; 2) inform learners of objective; 3) stimulate recall of prior knowledge. The second segment (instruction and practice) included: 4) present the content; 5) provide learning guidance; 6) elicit performance or practise; and 7) provide feedback. The last segment (assessment and transfer) consist of two last events: 8) assess performance; and 9) enhance retention and transfer. In outlining this research's theoretical model, all the nine event were used even it was not necessarily to include all events on all occasions (Smith & Ragan, 1996).

The development of the theoretical model was aided with four TTCT original constructs (Torrance, 1972b): 1) fluency; 2) flexibility; 3) originality; and 4) flexibility. The constructs were adapted for measuring creative thinking through colouring activity





















as 1) multiple colours; 2) multiple colouring techniques; 3) additional novel object; and 4) colour weight. Discussion on the TTCT instrumentation was discussed further in Chapter 4.

### 1.8 Research Scope

This research is conducted under the social science academic settings (see Figure 1.7). It focused on creative thinking skill among preschool children because during this age, their creative and colour exploring are being built in this age (Aminah Ayob, Nani Menon, Rohani Abdullah, & Jameyah Sheriff, 2013). Child creative thinking and aesthetic development milestones are attached in Appendix A for reference. As depicted by Pathways (2019), during the age four until six years old children are able to colour and begin to imitate shapes. Moreover, according to the Centers for Disease Control and Prevention (2015), preschool children should be able to identified colours, showing affection and show rapid development of mental skills. Child development milestones and four to six years abilities are attached in Appendix B and Appendix C for reference.

Even though the HOTs have two types of thinking, critical thinking was not included in the research because the ability to make critical judgement was more suitable for children six years old and above. In terms of limitation, this research was constrained by three matters, namely the participants, the device used to conduct the study and app including colouring worksheet.











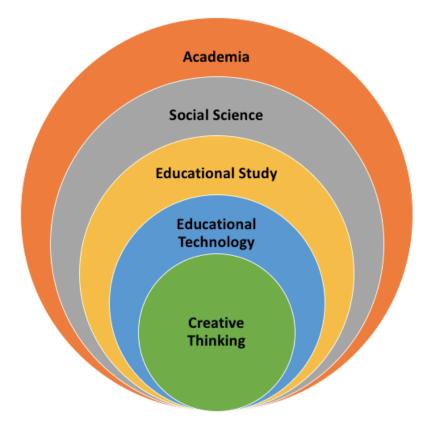


Figure 1.7. Scope and Position of Creative Thinking Studies in Academia
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#### 1.8.1 The Participants

This research was limited to Malaysian preschool children aged five and six years old, as opposed to all age groups in preschool childhood in Malaysia. As depicted by the Program Permata Negara module (Aminah Ayob et al., 2013), children older than four years old generally have sufficient cognitive capacity to express their creativity through colouring.

The participants of this research were recruited from two national preschools at the Kelantan area. The first school, School A is among several school in Malaysia,





















where the environment, facilities and facilitation was represent all the national preschool in Malaysia (refer to Section 3.8.1 in Chapter 3). The second school, School B was chosen as the second case for this research because of its unique roles and functions in Malaysia for the existence of a Samsung SMART Classroom (refer to Section 3.8.2 in Chapter 3). Two different setup of preschools have been chosen to conduct this research aiming to get a relatively unified finding and conclusion.

#### 1.8.2 The Device Used

The mobile devices used in first quasi-experimental study were five to ten inch tablet computers. However, for the second quasi-experimental study, only ten inch tablet computers used, instead of using smartphones with smaller screen size. The identical tablets would be used to collect data with the participants to get more consistent result.

### The App and Colouring Worksheet

The AR colouring mobile app used with permission in this research was called Quiver app (refer to Appendix D). It was install in android OS and used two colouring worksheets: 1) pukeko bird; and 2) dot day, was explain further details in Section 3.7.1 in Chapter 3. The size of the worksheet was A5 size. Student was asked to colour the objects only (regardless the background). This two justification were tested suitable to be complete within one hour teaching and learning session and were explained further in Chapter 3.





















#### 1.9 Significance of this Research

The first part of the research would offer a set of guiding principles can be referred by preschool teachers for teaching and learning assist by AR technology. The use of AR is an attempt to leverage ICT support and increase the level of creative thinking in education field. It is keen to explore the potential of mobile learning integration by utilizing the power of teaching and learning of the mobile devices. The significant pedagogical change is very important. Students in the 21st century need teachers who can apply digital technologies collaboratively to design effective and innovative learning environment (Partnership for 21st Century Learning, 2015).

The second part of the research would offer an AR assessment instrument for os-4506 measuring the creative thinking among preschool children. The assessment is part of the assessment for learning or formative assessment. It will be able teacher to provide future lesson to improve teaching and learning thereby improve the children performance.

The doctoral research was conducted to support education transformation that takes place over 13 years. Malaysian education mission is to pursue excellence with increased creative and critical thinking and improve performance on Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) in top third of the systems (Ministry of Education Malaysia, 2013).



















#### **Operational Definition** 1.10

There were five variables with phrases used along this research. The term was synthesized from the nominal meanings into one definition which is contextualize for this research title and context.

### 1.10.1 Creative Thinking

For this research, creative thinking is related to or involved the use of the original ideas, opinions and imagination to create coloured picture using colour pencil based on four TTCT construct (Torrance, 1972b); 1) fluency; 2) flexibility; 3) originality; and 4)









### **1.10.2 Fluency**

This research measures the level of creative thinking in which fluency construct shows the ability of using multiple colours.

# 1.10.3 Flexibility

Flexibility construct shows the ability of using multiple colouring techniques to create different texture in colouring.



















### 1.10.4 Originality

Originality construct refers to the ability of adding new object inside of the original uncoloured image.

### 1.10.5 Elaboration

Elaboration construct refers to the ability to complete the colouring task without left any space uncoloured.









This research was conducted to determine the effect of AR app towards creative thinking among preschool children specific in colouring activity. This chapter outlined the inspiration and motivation which lie behind the conduct of this research, the problem statements which lead to the research aims and research questions, the hypothetical propositions and presenting the research framework diagram. This chapter also clarified the significant, scope and limitation of the research and a few operational definitions that used in this research. Discussion on literature review regarding creative thinking, preschool, involvement of ICT and AR in education and discussion on the previous researches were further examined in next chapter, Chapter 2.









